ENVIRONMENTAL SENSITIVITY INDEX: DELAWARE, NEW JERSEY, AND PENNSYLVANIA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the shorelines of Delaware, New Jersey, and Pennsylvania, encompassing the outer coast from the Maryland-Delaware border north to Toms River, in Barnegat Bay, New Jersey and the Delaware Bay and River system to Trenton, New Jersey. The ESI maps include information for three main components: shoreline habitats; sensitive biological resources; and human-use resources. Background information, as well as the methods of data collection and presentation, are summarized in the following sections.

SHORELINE HABITAT MAPPING

The intertidal habitats of Delaware, New Jersey, and Pennsylvania were mapped during overflights conducted from 10-17 April 1995. The aerial surveys were conducted using helicopter, flying at elevations of 300-500 feet and slow air speed. An experienced coastal geologist updated the intertidal habitats originally mapped in 1985 on plots of 1:24,000 U.S. Geological Survey (USGS) topographic maps which had the original shoreline classification plotted on them. Where appropriate, multiple habitats were delineated for each shoreline segment.

Prediction of the behavior and persistence of oil on intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The vulnerability of a particular intertidal habitat is an integration of the following factors:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

All of these factors are used to determine the relative sensitivity of intertidal habitats. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate, shoreline type, product type, fate and effect, and sediment transport patterns. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline.

These concepts have been used in the development of the ESI, which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for the shorelines of Delaware, New Jersey, and Pennsylvania, presented in order of increasing sensitivity to spilled oil.

1) Exposed Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
2A) Eroding Bluffs
2B) Wave-cut Clay Platforms
3) Fine-grained Sand Beaches
4) Medium- to Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap Structures
7) Exposed Tidal Flats
8A) Vegetated, Steeply Sloping Riverine Bluffs
8B) Sheltered Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
9) Sheltered Tidal Flats
10) Salt and Brackish-water Marshes

Each of the shoreline habitats are described on pages 7-12, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

The biological information presented on the maps was compiled with the assistance of federal, state, and regional biologists and resource managers from the U.S. Fish and Wildlife Service, Delaware Department of Natural Resources and Environmental Control (DNREC), New Jersey Department of Environmental Protection and Energy (DEPE), and Pennsylvania Department of Environmental Resources (DER). Information collected and depicted on the maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Seven major categories of biological resources were considered during production of the maps: marine mammals, terrestrial mammals, birds, reptiles, fish, shellfish, and habitats.

Spatial distribution of the species on the maps is represented by polygons, lines, and points, as appropriate. Associated with each of these representations is an icon depicting the types of plants or animals that are present. Species have been divided into groups and subgroups, based on their behavior and taxonomic classification. The icons reflect this grouping scheme. The groups are color coded, and the subgroups are represented by different icons as follows:

MARINE MAMMALS


Dolphins


Seals


Whales

TERRESTRIAL MAMMALS


Small Mammals

BIRDS


Diving Birds


Gulls and Terns


Raptors


Shorebirds


Wading Birds


Waterfowl

REPTILES


Turtles

FISH


Fish

SHELLFISH


Bivalves


Cephalopods


Crabs


Gastropods


Lobsters

HABITATS


Submersed Aquatic Vegetation


Terrestrial Vegetation

The polygon, line, or point color and pattern are the same for all the animals in one group (i.e., birds). When there is more than one group of animals in one polygon, the polygon is then assigned the multigroup color and pattern. Also associated with each biological polygon, line, or point feature on the map is a number (located under the icon). This number references a table on the reverse side of the map with a complete list of species found in the polygon as well as seasonality and life-history information on each species.

There are some species that are found throughout the nearshore zone on the map. While it is important to note the presence of these species, showing these distributions as polygons would cover large areas, making the maps very difficult to read. Thus, species found in over 25 percent of the water area are identified in a box stating that they are "COMMON IN AREA". This approach informs the user of the presence of these species, while maintaining readability of the map.

For many biological resources, information and expert knowledge may not be available for all geographic locations. For this reason, absence of a resource on a map does not necessarily mean it is not present. Under the descriptions of the various biological resource groups, the geographical limits of available knowledge, or the survey boundaries of particular studies, are given when known.

MARINE MAMMALS

Three subgroups of marine mammals, seals, dolphins, and whales, are depicted for Delaware Bay and surrounding areas.

Harbor seals are sighted frequently throughout the area, while gray, harp, and hooded seals are sighted occasionally.

The bottlenose dolphin and harbor porpoise are common throughout the Bay and coastal area. Occasionally, the Atlantic white-sided dolphin, common dolphin, Risso's dolphin, rough-toothed dolphin, and stenellid dolphin are seen in the area. The humpback whale is also a frequent denizen of the Delaware Bay area. These animals have been seen in the Bay during their migrations. Other species of whales are included that are infrequent visitors, so that the full range of mammals that may be present in the Bay is included.

Marine mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first columngives the species name. The second and third columns denote whether the species has either state (S) and / or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

TERRESTRIAL MAMMALS

Terrestrial mammals included in the Delaware, New Jersey, and Pennsylvania atlas are river otter, raccoon, mink, and muskrat. These animals are found primarily in the wetlands along Delaware Bay. The river otters concentrate in the streams that feed into the Bay.

Terrestrial mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No terrestrial mammals included on the maps have such designations. The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

BIRDS

Birds are divided into several species subgroups based on behavior and taxonomy. The species table lists all the birds included on the maps, sorted by subgroup. These species were included either because of their likelihood of impact by an oil spill or special protection status as threatened or endangered. Of particular importance are the spring migratory shorebird concentrations in Delaware Bay. With 800,000 to 1,500,000 shorebirds present in the spring, Delaware Bay is one of the most significant migratory areas for shorebirds in the Western Hemisphere. Shorebirds are attracted by the spawning horseshoe crab. Delaware Bay area is a significant overwintering place for waterfowl. Pea Patch Island is also a major nesting site for various species of wading birds.

Bird distribution is shown on the maps as green hatch polygons. These areas depict known migratory, overwintering, nesting, or other concentration areas. Green dots on the maps represent the location of nesting colonies. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name, followed by the state (S) and/or federal (F) species designation for endangered (E) or threatened (T) status. The species will be identified as threatened or endangered for all occurrences of the species, even if it is only listed as such in one state. The next column provides an estimate of the concentration of each species at the site. For birds, the highest count of individuals recorded at each site is given. Where counts were not available, "Unknown" is listed in the concentration column. Even though concentration may be listed as "Unknown", it should be recognized that the number of individuals or the importance of the site was still significant enough to be included. The species seasonality is shown in the next twelve columns representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. The last column denotes the nesting season for each species, if nesting occurs at the site. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

REPTILES

The only reptiles included in the Delaware, New Jersey, and Pennsylvania atlas are sea turtles and northern diamondback terrapins. There are no known sea turtle nesting beaches present in the area. The in-water areas represent known foraging, developmental, migratory, or other habitat areas where sea turtles are likely to occur in substantial numbers. Northern diamondback terrapins are a species of special concern and are known to nest in the Delaware and New Jersey area. The maps show known concentration areas rather than nesting sites.

Turtle distributions are shown as polygons with a red hatch pattern. If species in addition to turtles are included in a polygon, a black hatch (multigroup) pattern is used. A red icon with a turtle silhouette is used to indicate the presence of turtles. The number under the icon references a table on the reverse side of the map. In the tables, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of the species at a site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". Concentration estimates are subjective based on local expert opinion on relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

FISH

The fish species included in the Delaware, New Jersey, and Pennsylvania atlas are those of commercial or recreational importance. The species table lists all of the species of fish included on the maps, grouped by anadromous and all other species. There are many more species of fish than those shown on the maps. In addition, most areas depicted reflect only the more significant concentrations. These areas are identified because of higher concentrations, important spawning areas, important juvenile areas, or high use recreational and/or commercial fishing for the named species.

The distributions of fish are shown as polygons with a blue hatch pattern. If species in addition to fish are included in the polygon, a black hatch (multigroup) pattern is used. A blue icon with a fish silhouette is used to indicate the presence of fish. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for outmigration, spawning, and the presence of juveniles. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

SHELLFISH

Shellfish included in the Delaware, New Jersey, and Pennsylvania atlas include bivalves (clams and oysters), cephalopods (squid), crabs, gastropods (whelk), and lobsters. The species table lists all the shellfish shown on the maps, sorted by subgroup. Commercially or recreationally important species are included. For clams, only moderate to high concentration areas are depicted. For oysters, the seed beds, lease beds, and general concentration areas have not been differentiated; all of these features are shown as oyster beds. Whelk concentration areas are shown in the lower portion of Delaware Bay, which is an important whelk fishing area.

Horseshoe crab concentration areas are shown for Delaware Bay. This is an important species because tremendous numbers (as many as 1.2 million in a single day) mate every year on the sand beaches of the lower bay. This activity attracts numerous shorebirds during their spring migration.

The distributions of shellfish are shown as polygons with an orange hatch pattern. If species in addition to shellfish are included in the polygon, a black hatch (multigroup) pattern is used. Orange icons are associated with the polygons, and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No shellfish included on the maps have such designations. The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for spawning, mating, and the presence of juveniles. Spawning refers to the release of gametes to the water column during reproductive periods, or the mass release of larvae. Mating applies to shellfish which form temporary reproductive pairs for fertilization of gametes (e.g., blue crabs), with later release of more developed larval young. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

HABITATS

Habitats included in the Delaware, New Jersey, and Pennsylvania atlas include seagrasses and terrestrial plants. Seagrasses in Delaware and New Jersey consist of eelgrass. For most oil spills, the many small animals associated with seagrass habitats are often at greater risk than the vegetation. The seagrasses are limited to the northern sections of Barnegat Bay and the eastern edge of the Indian River and Rehoboth Bays.

Habitats are shown as polygons with a purple hatch pattern. If species in addition to plants are present in the polygons, a black hatch (multigroup) pattern is used. Purple icons are associated with the polygons and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. The concentration column provides an estimate of the plant abundance at the site. Concentration for seagrasses and terrestrial plants are unknown, since the source information only indicated presence or absence. The last twelve columns provide information on seasonality. All 12 months are marked with an "X" since the plants are present all year. However, it should be recognized that during winter months, above-ground vegetation may be reduced or not present.

HUMAN-USE FEATURES

The human-use features depicted on the maps are those that either could be impacted by an oil spill or could provide access for response operations. All the features are represented by icons indicating the type of human-use resource.

ACCESS POINT

Locations where it is possible to gain vehicle access to the shoreline.

AIRPORT

Location of airfields or airports, whether manned or unmanned. The locations were obtained from USGS 1:24,000 topographic maps.

ARCHAEOLOGICAL SITE

Location of known archaeological sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

BOAT RAMP

Location of boat ramps. These data were obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

COAST GUARD

Location of Coast Guard facilities. This information was obtained from visual observation during overflights and from USGS 1:24,000 topographic maps.

FERRY

Location of ferry docks. This information was obtained from USGS 1:24,000 topographic maps.

HISTORICAL SITE

Location of historical sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

MARINA

Location of marinas. This information was obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

PARK

Location of state parks. The boundaries were obtained from the U.S. Fish and Wildlife Service, the New Jersey Department of Environmental Protection and Energy, and from USGS 1:24,000 topographic maps.

RECREATIONAL FISHING OR BOATING

General areas where there is heavy recreational fishing or boating. These areas were provided by the Delaware Department of Natural Resources and Environmental Control.

RESERVE, PRESERVE, OR REFUGE

All boundaries for the reserves, preserves, refuges, or any other managed and regulated wildlife areas were provided by the U.S. Fish and Wildlife Service and the New Jersey Department of Environmental Protection and Energy. These managed lands include an icon and the name of the property.

WATER INTAKES

Location of surface water intakes whether for cooling water, industrial use, or potable water. All public and private surface water intakes are shown. Information was provided by the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

For water intakes, the name of the resource, the manager/ owner, an emergency contact person, and a telephone number are provided. The information is listed on the reverse side of the maps, when available.

GEOGRAPHIC INFORMATION SYSTEM DATA

The entire atlas product is stored in digital form in a Geographic Information System (GIS). The information is stored as maps and associated databases. The format for the data varies depending on the type of information or features for which the data are being stored. The three major formats are shoreline habitat classification, biological resources, and human-use features.

Under separate cover are a complete data dictionary, metadata, and descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Please refer to the metadata file for full explanations of the data and its structure.

SHORELINE HABITAT CLASSIFICATION

The shoreline habitat classification is stored as lines with the data identifying the type of habitat associated with the line. In many cases, a shoreline may have two classifications. These multiple classifications are represented on the maps by double lines and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are shown on the map as lines, points, or polygons. Associated with each map feature is a unique identification number which is linked to a series of databases that further identify the resources. The first data set consists of a list of the species and the concentration of each species. This dataset is then linked to a dataset that describes the life history of each species (temporal presence and reproductive times at month resolution) for the specified map feature. Other databases linked to the first data set are the species identification database, which includes common and scientific names for all species and their threatened or endangered status, and the sources database, which provides source metadata at the feature level.

HUMAN-USE FEATURES

Human-use features are represented on the maps as an icon describing the feature. In the digital file, the feature location is represented by a point or by polygons. If the feature is either an aquaculture facility or water intake, a data file that contains the fields for the name of the owner/manager, telephone number at which the person can be contacted, identification of the type of feature, and a brief description of the feature is associated with the feature. For all of the other human-use features, only the name, when available, is entered into the database.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication concerning resources depicted in the atlas.

Bellrose, F., 1980, Ducks, geese, and swans of North America: Wildlife Management Institute, Washington, D.C., 540 pp.

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Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jary, M.E. Monaco, and L. Anderson, 1994, Distribution and abundance of fishes and invertebrates in mid-Atlantic estuaries: ELMR Rept. No. 12, NOAA/NOS Strategic Environmental Assessment Division, Silver Spring, Md., 280 pp.

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At Research Planning, Inc. (RPI), Joanne Halls and Mark White were the project managers. Shoreline mapping was conducted by Todd M. Montello. Biological and human-use resources data were collected and compiled by Jeffrey Dahlin. Mark White, Lee Diveley, Kara Hastings, and James Olsen entered the data and produced the final maps, under the supervision of Joanne Halls. Systems administration was coordinated by Bill Holton. Graphics were provided by Joe Holmes and Becky Cox, and Dot Zaino prepared the text.

SPECIES LIST*

Common Name	Species Name
MARINE MAMMALS	
DOLPHINS	
Atlantic white-sided dolphin	*Lagenorhynchus acutus*
Bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Harbor porpoise	*Phocoena phocoena*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Stenellid dolphin	*Stenella sp.*
SEALS	
Gray seal	*Halichoerus grypus*
Harbor seal	*Phoca vitulina*
Harp seal	*Pagophilus groenlandicus*
Hooded seal	*Cystophora cristata*
WHALES	
Bryde's whale	*Balaenoptera edeni*
Dwarf sperm whale	*Kogia simus*
Fin whale (DE, NJ)	*Balaenoptera physalus*
Humpback whale (DE, NJ)	*Megaptera novaeangliae*
Long-finned pilot whale	*Globicephala melaena*
Minke whale	*Balaenoptera acutorostrata*
Northern right whale (DE, NJ)	*Eubalaena glacialis*
Pygmy sperm whale	*Kogia breviceps*
Sei whale (DE, NJ)	*Balaenoptera borealis*
Shortfin pilot whale	*Globicephala macrorhynchus*
Sperm whale (NJ)	*Physeter catodon*
TERRESTRIAL MAMMALS	
SMALL MAMMALS	
Mink	*Mustela vison*
Muskrat	*Ondatra zibethicus*
Northern raccoon	*Procyon lotor*
River otter	*Lutra canadensis*
BIRDS	
DIVING BIRDS	
Brown pelican (DE)	*Pelecanus occidentalis*
Double-crested cormorant	*Phalacrocorax auritus*
Great cormorant	*Phalacrocorax carbo*
Pied-billed grebe	*Podilymbus podiceps*
GULLS AND TERNS	
Black skimmer (NJ)	*Rynchops niger*
Black tern	*Chlidonias niger*
Common tern	*Sterna hirundo*
Forster's tern	*Sterna fosteri*
Great black-backed gull	*Larus marinus*
Gull-billed tern	*Sterna nilotica*
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Least tern (NJ)	*Sterna antillarum*
Ring-billed gull	*Larus delawarensis*
Roseate tern (NJ)	*Sterna dougallii*
RAPTORS	
Bald eagle (DE, NJ)	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Osprey (NJ)	*Pandion haliaetus*
Peregrine falcon (DE, NJ)	*Falco peregrinus*
SHOREBIRDS	
American oystercatcher	*Haematopus palliatus*
Greater yellowlegs	*Tringa melanaleuca*
Least sandpiper	*Calidris minutilla*
Lesser yellowlegs	*Tringa flavipes*
Piping plover (DE, NJ)	*Charadrius melodus*
Semipalmated sandpiper	*Calidris pusilla*
Solitary sandpiper	*Tringa solitaria*
Spotted sandpiper	*Actitis macularia*
WADING BIRDS	
Black-crowned night heron	*Nycticorax nycticorax*
Cattle egret	*Bubulcus ibis*
Glossy ibis	*Plegadis falcinellus*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Green-backed heron	*Butorides striatus*
King rail	*Rallus elegans*
Least bittern	*Ixobrychus exilis*
Little blue heron	*Egretta caerulea*
Snowy egret	*Egretta thula*
Sora rail	*Porzana carolina*
Tricolored heron	*Egretta tricolor*
Virginia rail	*Rallus limicola*
Yellow-crowned night heron (NJ)	*Nyctanassa violacea*

SPECIES LIST*

Common Name	Species Name
BIRDS (continued)	
WATERFOWL	
American coot	*Fulica americana*
American wigeon	*Anas americana*
Black duck	*Anas rubripes*
Blue-winged teal	*Anas discors*
Brant	*Branta bernicla*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Common eider	*Somateria mollissima*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Common moorhen	*Gallinula chloropus*
Gadwall	*Anas strepera*
Goldeneye	*Bucephala spp.*
Greater scaup	*Aythya marila*
Green-winged teal	*Anas crecca*
Hooded merganser	*Lophodytes cucullatus*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Merganser	*Mergus spp.*
Mute swan	*Lygnus olor*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Oldsquaw	*Clangula hyemalis*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Scaup	*Aythya spp.*
Scoter	*Melanitta spp.*
Snow goose	*Chen caerulescens*
Surf scoter	*Melanitta perspicillata*
Whistling swan (tundra swan)	*Olor columbianus*
White-winged scoter	*Melanitta deglandi*
Wood duck	*Aix sponsa*
REPTILES	
TURTLES	
Diamondback terrapin	*Malaclemys terrapin*
Green sea turtle (DE)	*Chelonia mydas*
Kemp's ridley sea turtle (DE, NJ)	*Lepidochelys kempi*
Loggerhead sea turtle (DE, NJ)	*Caretta caretta*
FISH	
ANADROMOUS	
Alewife	*Alosa pseudoharengus*
American shad	*Alosa sapidissima*
Atlantic sturgeon	*Acipenser oxyrhynchus*
Blueback herring	*Alosa aestivalis*
Shortnose sturgeon (DE, NJ, PA)	*Acipenser brevirostrum*
Striped bass	*Morone saxatilis*
SPECIAL CONCENTRATIONS	
Atlantic croaker	*Micropogonias undulatus*
Atlantic herring	*Clupea harengus harengus*
Atlantic menhaden	*Brevoortia tyrannus*
Bay anchovy	*Anchoa mitchilli*
Black drum	*Pogonias cromis*
Black seabass	*Centropristis striata*
Bluefish	*Pomatomus saltatrix*
Channel catfish	*Ictalurus punctatus*
Largemouth bass	*Micropterus salmoides*
Northern kingfish	*Menticirrhus saxatilis*
Porgy (scup)	*Stenotomus chrysops*
Seatrout (weakfish)	*Cynoscion regalis*
Spot	*Leiostomus xanthurus*
Squirrel (red) hake (ling)	*Urophycis chuss*
Summer flounder	*Paralichthys dentatus*
Tautog	*Tautoga onitis*
White perch	*Morone americana*
Winter flounder	*Pseudopleuronectes americanus*
Yellow perch	*Perca flavescens*

* Threatened and endangered species are designated by underlining; the state for which they are either threatened or endangered is indicated in parenthesis.

SPECIES LIST*

Common Name	Species Name
SHELLFISH	
BIVALVES	
American oyster (eastern)	*Crassostrea virginica*
Northern quahog (hard clam)	*Mercenaria mercenaria*
CEPHALOPOD	
Squid	*Loligo sp.*
CRABS	
Blue crab	*Callinectes sapidus*
Horseshoe crab	*Limulus polyphemus*
GASTROPOD	
Channeled whelk	*Busycon canaliculatum*
Knobbed whelk	*Busycon carica*
LOBSTER	
Northern lobster	*Homarus americanus*
HABITATS	
SUBMERSED AQUATIC VEGETATION	
Eelgrass	*Zostera marina*
Minute duckweed (NJ)	*Lemna perpusilla*
TERRESTRIAL VEGETATION	
American cupscale (NJ)	*Sacciolepis striata*
Awl-leaved rush (NJ)	*Juncus coriaceus*
Barton's St. John's-wort (NJ)	*Hypericum adpressum*
Beach amaranth (NJ)	*Amaranthus pumilus*
Black-based quillwort (NJ)	*Isoetes melanopoda*
Black-fruited spikerush (NJ)	*Eleocharis melanocarpa*
Bog asphodel (NJ)	*Narthecium americanum*
Boykin's lobelia (NJ)	*Lobelia boykinii*
Britton's spikerush (NJ)	*Eleocharis brittonii*
Bur-marigold (NJ)	*Bidens bidentoides*
Clustered beaked rush (NJ)	*Rhynchospora glomerata*
Coast flatsedge (NJ)	*Cyperus polystachyos*
Cut-leaved water-milfoil (NJ)	*Myriophyllum pinnatum*
Cypress-swamp sedge (NJ)	*Carex joorii*
Featherfoil (NJ)	*Hottonia inflata*
Floating pennywort (NJ)	*Hydrocotyle ranunculoides*
Fog fruit (NJ)	*Phyla lanceolata*
Glade spurge (NJ)	*Euphorbia purpurea*
Grass-like beaked rush (NJ)	*Rhynchospora globularis*
Knieskern's beaked rush (NJ)	*Rhynchospora knieskernii*
Koehn's tooth-cup (NJ)	*Ammannia latifolia*
Lace-lip ladies'-tresses (NJ)	*Spiranthes laciniata*
Larger buttonweed (NJ)	*Diodia virginiana*
Lesser bladderwort (NJ)	*Utricularia minor*
Long's bulrush (NJ)	*Scirpus longii*
Mudweed (NJ)	*Limosella subulata*
New Jersey rush (NJ)	*Juncus caesariensis*
Pine Barren boneset (NJ)	*Eupatorium resinosum*
Pumpkin Ash (NJ)	*Fraxinus profunda*
Puttyroot (NJ)	*Aplectrum hyemale*
Rare-flowering beaked rush (NJ)	*Rhynchospora rariflora*
Red goosefoot (NJ)	*Chenopodium rubrum*
Robin-run-away (NJ)	*Dalibarda repens*
Rough cottongrass (NJ)	*Eriophorum tenellum*
Rough flatsedge (NJ)	*Cyperus retrofractus*
Salt marsh bulrush (NJ)	*Scirpus robustus*
Sea-beach milkwort (NJ)	*Glaux maritima*
Sea-side evening primrose (NJ)	*Oenothera humifusa*
Seaside alder	*Alnus maritima*
Seaside crowfoot (NJ)	*Ranunculus cymbalaria*
Short-fruited rush (NJ)	*Juncus brachycarpus*
Slender water-milfoil (NJ)	*Myriophyllum tenellum*
Small yellow pond lily (NJ)	*Nuphar microphyllum*
Small-headed beaked rush (NJ)	*Rhynchospora microcephala*
Snowy orchid (NJ)	*Platanthera nivea*
Stinking fleabane (NJ)	*Pluchea foetida*
Stout smartweed (NJ)	*Polygonum densiflorum*
Swamp-pink (NJ)	*Helonias bullata*
Thread-leaved beaked rush (NJ)	*Rhynchospora filifolia*
Twisted spikerush (NJ)	*Eleocharis tortilis*
Virginia joint-vetch (NJ)	*Aeschynomene virginica*
Virginia thistle (NJ)	*Cirsium virginianum*
Walter's St. John's-wort (NJ)	*Triadenum walteri*
Water oak (NJ)	*Quercus nigra*
Whorled nut rush (NJ)	*Scleria verticillata*
Wrinkled jointgrass (NJ)	*Coelorachis rugosa*

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Shoreline Habitat Descriptions

EXPOSED SEAWALLS AND OTHER SOLID STRUCTURES
MADE OF CONCRETE, WOOD, OR METAL ESI = 1

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- Often there is no exposed beach at low tide, but multiple habitats are indicated if present.
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes.
- They are heavily utilized by the public for shoreline-based fishing.
- Attached animals and plants are sparse.
- They are common along the Delaware River shoreline.

PREDICTED OIL BEHAVIOR

- Oil is often held offshore by waves reflecting off the steep structures.
- Any oil that is deposited is rapidly removed from exposed faces.
- The most resistant oil would remain as a patchy band at or above the high-tide line.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- Access can be difficult and dangerous.
- High-pressure water spraying may be required to:
  - remove persistent oil;
  - improve aesthetics; or
  - prevent leaching of oil from the structure.

ERODING BLUFFS ESI = 2A

DESCRIPTION

- This shoreline type occurs where sandy bluffs are undercut by river currents and slump.
- They normally form along embankments of sandy dredge-spoil material.
- Some scarps are fronted by narrow beaches, if the erosion rate is moderate or episodic.
- Biological utilization by infauna and birds is low.
- This shoreline type is uncommon and found primarily along the banks of the Maurice River and other rivers in the area.

PREDICTED OIL BEHAVIOR

- Oil will concentrate at the high water line, with the potential for penetration up to 10 cm into the sandy sediments.
- There is little potential for burial except when a major slumping of the bluff occurs.

RESPONSE CONSIDERATIONS

- Cleanup should concentrate on the removal of oil after all oil has come ashore.
- Manual cleanup is advised to minimize the volume of sand removed from the shore and requiring disposal, and reduce the risk of increased slumping and bluff erosion.
- All efforts should focus on preventing the mixture of oil deeper into the sediments.

WAVE-CUT CLAY PLATFORMS ESI = 2B

DESCRIPTION

- These shoreline types form by wave or boat wake erosion of muddy substrates along navigation channels, the river shorelines, and bay shores.
- They are characterized by a narrow shelf or platform that can be flooded depending on water levels.
- There can be burrowing animals in the mud.
- They are of very limited extent along the western shore of Delaware Bay.

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet clay surface, but could penetrate the burrows if present and dry.
- Persistence of oil is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- Where the high-tide area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris.
- The muddy substrate cannot support heavy equipment, and even foot traffic could disrupt the sediments and mix oil deeper.

FINE-GRAINED SAND BEACHES ESI = 3

DESCRIPTION

- These beaches are generally flat and hard-packed.
- They are commonly backed by dunes or seawalls.
- They are utilized by birds for nesting, foraging, and loafing.
- Upper beach fauna are scarce; lower beach fauna can be dense, but are highly variable.
- These beaches are common along the outer coast of southern New Jersey.

PREDICTED OIL BEHAVIOR

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide.
- Maximum penetration of oil into fine-grained sand is about 10 cm.
- Burial of oiled layers by clean sand within the first few weeks after a spill typically will be less than 30 cm along the upper beach face.
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infaunal populations, which can also affect important shorebird foraging areas.

RESPONSE CONSIDERATIONS

- These beaches are among the easiest shoreline types to clean.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Activity through both oiled and dune areas should be severely limited, to prevent contamination of clean areas.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments from the high-tide zone to the upper intertidal zone can be effective along the Atlantic shore.

MEDIUM- TO COARSE-GRAINED SAND BEACHES ESI = 4

DESCRIPTION

- These beaches are moderate-to-steep, of variable width, and have soft sediments.
- Generally species density and diversity is lower than on fine-grained sand beaches.
- They are common along the outer beaches of Delaware and northern New Jersey.

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited primarily as a band along the high-tide line.
- Under very heavy accumulations, oil may spread across the entire beach face, though the oil will be lifted off the lower part of the beach with the rising tide.
- Penetration of oil into coarse-grained sand can reach 25 cm.
- Burial of oiled layers by clean sand can be rapid, and to depths of 60 cm or more.
- Burial to depths over one meter is possible if the oil comes ashore at the start of a depositional period.
- Biological impacts include temporary declines in infaunal populations, which can also affect important shorebird foraging areas.

RESPONSE CONSIDERATIONS

- Remove oil primarily from the upper swash lines.
- Removal of sediment should be limited to avoid erosion problems.
- Mechanical reworking of the sediment into the surf zone may be used to release the oil without sediment removal.
- Activity in the oiled sand should be limited to prevent mixing oil deeper into the beach.
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more effective.

MIXED SAND AND GRAVEL BEACHES ESI = 5

DESCRIPTION

- Moderately sloping beach composed of a mixture of sand and gravel.
- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles.
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms.
- Because of sediment desiccation and mobility on exposed beaches, there are low densities of attached animals and plants.
- The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.
- They are found along the Delaware Bay shoreline.

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along and above the high-tide swash.
- Large spills will spread across the entire intertidal area.
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent.
- Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves.
- In sheltered pockets on the beach, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, because most of the oil remains on the surface.
- Once formed, these asphalt pavements can persist for many years.
- Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil has picked up sediments.

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil from the upper beachface.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones.
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers in the middle zone on exposed beaches.

GRAVEL BEACHES ESI = 6A

DESCRIPTION

- Gravel beaches are composed of sediments ranging in size from pebbles to boulders.
- They can be very steep, with multiple wave-built berms forming the upper beach.
- Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile.
- The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.
- Gravel beaches are common and present in various localities along the Delaware River.

PREDICTED OIL BEHAVIOR

- Deep penetration and rapid burial of stranded oil is likely on exposed beaches.
- On exposed beaches, oil can be pushed over the high-tide and storm berms, pooling and persisting above the normal zone of wave wash.
- Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves.
- On the more sheltered portions of beaches, formation of asphalt pavements is likely where accumulations are heavy.

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed quickly from the upper beach.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low- to high-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents.
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers in the middle intertidal zone on exposed beaches.

RIPRAP STRUCTURES **ESI = 6B**

DESCRIPTION

- Riprap structures are composed of cobble- to boulder-sized blocks of rock.
- Riprap structures are placed for shoreline protection and inlet stabilization.
- Attached biota on the riprap can be sparse.
- These structures are highly utilized for shore-based fishing.
- Riprap structures are relatively common along the Delaware River shoreline and in developed areas throughout the region.

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely.
- Oil adheres readily to the rough rock surfaces.
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens.

RESPONSE CONSIDERATIONS

- When the oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective, making sure to recover all released oil.
- Heavy and weathered oils are more difficult to remove, requiring scrapping and/or hot-water spraying.
- It may be necessary to remove heavily oiled riprap and replace it.

EXPOSED TIDAL FLATS **ESI = 7**

DESCRIPTION

- Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of shell and mud.
- The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments.
- They are often associated with another shoreline type on the landward side of the flat and are most commonly associated with tidal inlet systems.
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.
- They are common at inlets along the Atlantic shoreline and the mouths of creeks within Delaware Bay.

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil does not penetrate water-saturated sediments, but can penetrate the sand and burrows if they dry out.
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.

RESPONSE CONSIDERATIONS

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup is very difficult (and possible only during low tides).
- The use of heavy machinery should be restricted to prevent mixing of oil into the sediments.
- On exposed sand flats, oil will be removed naturally from the flat and deposited on the adjacent beaches where cleanup is more feasible.

VEGETATED, STEEPLY SLOPING RIVERINE BLUFFS ESI = 8A

DESCRIPTION

- Either low banks with grasses or low eroding banks with trees and tree roots exposed to the water.
- Flooded occasionally by high water.
- These shorelines are generally found in fresh or brackish water localities.

PREDICTED OIL BEHAVIOR

- During low water stages there is little impact, with the oil coating a narrow band of sediment at the water level.
- During high water, the oil will cover and coat the grasses and base of the trees.
- May cause loss of the grasses, but the trees should survive unless oil penetrates and persists in the substrate.

RESPONSE CONSIDERATIONS

- Low-pressure flushing of oiled areas is effective in removing moderate to heavy accumulations of oil from along the banks.
- Sorbent and containment boom should be placed on the water side of the cleanup operations to contain and collect oil outflow.
- Low- to high-pressure flushing can be used to remove oil from tree roots and trunks, if deemed necessary in high-use areas.

SHELTERED SEAWALLS AND OTHER SOLID STRUCTURES MADE OF CONCRETE, WOOD, OR METAL ESI = 8B

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- Often there is no exposed beach at low tide, but multiple habitats are indicated if present.
- Most of the structures in bays are designed to protect a single lot, thus their composition, design, and condition are highly variable.
- They can have high recreational use, particularly in public areas.
- Attached animal and plant life can be sparse.
- This shoreline type is common throughout the developed areas of the region.

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to the rough surface, particularly along the high-tide line, forming a distinct oil band.
- The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface.

RESPONSE CONSIDERATIONS

- Cleanup is usually conducted for aesthetic reasons or to prevent leaching of oil.
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.

SHELTERED TIDAL FLATS ESI = 9

DESCRIPTION

- Sheltered tidal flats are composed primarily of silt and clay with minor amounts of sand and shell.
- Wave energy is very low, although there may be strong tidal currents on parts of the flat and in channels across the flat.
- The sediments are very soft and cannot support even light foot traffic in many areas.
- There can be large populations of shellfish, worms, and snails.
- They are heavily utilized by birds for feeding and roosting.
- They are present in calm-water habitats, sheltered from major wave activity, and are frequently backed by marshes.

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and mud-cracked sediments.
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the flats.
- Biological damage may be severe.

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; deflection or sorbent booms and open water skimmers should be used.
- Cleanup of the flat surface is very difficult because of the soft substrate and many methods may be restricted.
- Water flooding and deployment of sorbents from shallow-draft boats may be helpful.

SALT AND BRACKISH-WATER MARSHES ESI = 10

DESCRIPTION

- Marshes are intertidal wetlands containing emergent, herbaceous vegetation.
- Width of the marsh can vary widely, from a narrow fringe to extensive areas.
- They are relatively sheltered from waves and strong tidal currents.
- Sediments are composed of organic-rich muds except on the margins of barrier islands where sand is abundant.
- Resident flora and fauna are abundant with numerous species and high utilization by birds.
- They are very common along the Delaware and New Jersey shorelines, especially within Delaware Bay.

PREDICTED OIL BEHAVIOR

- Oil adheres readily to marsh vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands.
- Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base.
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of tidal influence.
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows.
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter).

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized.
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.